

## WHAT IS CLAIMED IS:

1. Illumination system for wavelengths  $\leq 193$  nm, particularly for EUV lithography with

- 1.1 at least one light source (1) which has an illumination A in a predetermined surface;
- 1.2 at least one device for the production of secondary light sources;
- 1.3 at least one mirror or lens device comprising at least one mirror or one lens, which is or are organized into raster element(s);
- 1.4 one or more optical elements, which are arranged between the mirror or lens device comprising at least one mirror or one lens, which is or are organized into raster element(s), and the reticle plane (14, 316, 406), whereby the optical elements image the secondary light source in the exit pupil of the illumination system;

the illumination system is characterized in that

- 1.5 the raster elements of the one or more mirrors or lenses are shaped and arranged in such a way that the images of the raster elements by means of the optical elements are overlapping for the most part of the reticle plane (14, 316, 406),

and that the exit pupil defined by the aperture and the degree of filling is illuminated.

2. Illumination system according to claim 1, further characterized in that the optical elements comprise at least one field mirror (32, 314, 416) or at least one field lens.

3. Illumination system according to claim 2, further characterized in that at most two field mirrors (32, 314, 416) or field lenses are provided.

4. Illumination system according to claim 2 or 3, further characterized in that

the field mirrors (32, 316, 416) are arranged in striped incidence.

5. Illumination system according to one of claims 1 to 4, further characterized in that

the mirror device comprises a mirror or a lens with raster elements, which are formed as field honeycombs (5).

6. Illumination system according to claim 5, further characterized in that the field honeycombs (5) in their aspect ratio essentially correspond to that of the field to be illuminated in the reticle plane.

7. Illumination system according to claim 5 or 6, further characterized in that

the mirrors or the lenses with raster elements produce the secondary light sources.

8. Illumination system according to one of claims 1 to 7, further characterized in that

the illumination system comprises a collector mirror or collector lens(es) (300, 402), which collects or collect the light from the light source.

9. Illumination system according to claim 8, further characterized in that the collector mirror and the mirror with raster elements or the collector lens and the lens with raster elements produce the secondary light sources.

10. Illumination system according to one of claims 1 to 9, further characterized in that

a light source (1) is provided, which radiates radially in a steradian greater than  $\pi/2$ , particularly a plasma focus source.

11. Illumination system according to one of claims 1 to 9, further characterized in that

a light source (1) is provided, which radiates directionally in a steradian smaller than  $\pi/2$ , particularly a pinch-plasma source.

12. Illumination system according to one of claims 1 to 11, further characterized in that

the mirror device comprises two mirrors or lenses with raster elements, a first mirror or a lens with a multiple number of field honeycombs (5) and a second mirror or lens with a multiple number of pupil honeycombs (9).

13. Illumination system according to claim 12, further characterized in that the field honeycombs are arranged on the first mirror or the first lens in such a way that they do not overlap and their images cover the surface to be illuminated in the reticle plane.

14. Illumination system according to claim 12 or 13, further characterized in that

the pupil honeycombs are arranged on the second mirror or the lens in such a way that their images, which are produced by the optical elements, illuminate the exit pupil with a predetermined pattern.

15. Illumination system according to claim 14, further characterized in that by a corresponding arrangement, particularly by rotating and tilting of

field and pupil honeycombs relative to one another, a light path will be constructed between a pair of field and pupil honeycombs.

16. Illumination system according to claim 14, further characterized in that a light path is constructed between a pair of field and pupil honeycombs by orienting and selecting the deflection angle of the prismatic component of the field and pupil honeycombs.

17. Illumination system according to one of claims 1 to 15, further characterized in that

a zigzag beam path is produced by field and pupil planes, particularly Köhler illumination.

18. Illumination system according to one of claims 1 to 13, further characterized in that

the mirror or lens system comprises a telescope system.

19. Illumination system according to claim 18, further characterized in that at least one mirror or one lens comprises the raster element or elements, and at the same time is one mirror or one lens of the telescope objective.

20. Illumination system according to claim 18 or 19, further characterized in that

the telescope system comprises the collector mirror (300, 402) or the collector lens.

21. Illumination system according to claim 20, further characterized in that the telescope system additionally comprises the first mirror or the first lens with a multiple number of field honeycombs, whereby the collector

mirrors have positive refractive power and the first mirror or the first lens have negative refractive power.

22. Illumination system according to claim 18, further characterized in that the telescope system comprises the first mirror or the first lens with a multiple number of field honeycombs and the second mirror or the second lens with a multiple number of pupil honeycombs, whereby the first mirror or the first lens has positive refractive power and the second mirror or the second lens has negative refractive power.

23. Illumination system according to at least one of claims 1 to 22, further characterized in that

the distance from the light source to the field to be illuminated is smaller than 3 m, and is preferably smaller than 2 m.

24. Illumination system according to one of claims 1 to 23, further characterized in that

the system comprises precisely three, four or five mirrors, at least one of which has striped incidence and at least one with raster elements.

25. Illumination system according to one of claims 1 to 23, further characterized in that

the system comprises precisely four or five mirrors, at least two of which with grazing incidence and at least two with raster elements.

26. Illumination system according to at least one of claims 1 to 25, further characterized in that

the raster elements of at least one mirror are curved, particularly in a concave or convex manner.

27. Illumination system according to at least one of claims 1 to 26, further characterized in that

the raster elements of at least one mirror are planar.

28. Illumination system according to one of claims 26 to 27, further characterized in that

the surfaces of the raster elements of at least one mirror are arranged on a curved surface.

29. Illumination system according to at least one of claims 1 to 27, further characterized in that

the raster elements of at least one mirror are arranged on a basic structure according to a type of Fresnel lens.

30. Illumination system according to at least one of claims 1 to 29, further characterized in that

the raster elements of at least one mirror are tilted relative to the enveloping or bearing surface.

31. Illumination system according to at least one of claims 1 to 30, further characterized in that

the raster elements of at least one mirror are arranged in rows and each time adjacent rows are arranged displaced relative to one another by a fraction, preferably  $\frac{1}{2}$  to  $\frac{1}{10}$  of the length of a raster element.

32. Illumination system according to at least one of claims 1 to 31, further characterized in that

at least one steradian component of the light radiated from the light source of  $0.5 \pi$ , preferably  $\pi$  and greater, is transported to the field.

33. Illumination system according to at least one of claims 1 to 32, further characterized in that

the mirror system has an axial symmetric construction with central vignetting.

34. Illumination system according to at least one of claims 1 to 32, further characterized in that

the mirror system has an outer axial course of the light bundle that is free of vignetting.

35. Illumination system according to at least one of claims 1 to 34, further characterized in that

the aspect ratio of the raster element of a mirror amounts to 1:1 to 1:20.

36. Illumination system according to at least one of claims 1 to 35, further characterized in that

the field is a rectangular field or an annular segment, as is usual in scanning projection lithography.

37. Illumination system according to at least one of claims 1 to 36, further characterized in that

at least one field mirror has a toroidal form, whereby the cross sections can also have conical and aspherical components.

38. Illumination system according to at least one of claims 1 to 37, further characterized in that

optical elements, particularly field mirrors, are provided, which fulfill one or more of the following functions:

--imaging of the secondary light sources in the entrance pupil of the subsequent projection objective

--remodeling of the pre-given rectangular illumination by raster elements to form a field in the form of an annular segment.

--adjustment of the intensity distribution over the field.

39. Illumination system according to at least one of claims 1 to 38, further characterized in that

at least one mirror has a reflectivity being position-dependent.

40. Illumination system according to at least one of claims 1 to 39, further characterized in that

the field-side numerical aperture amounts to approximately 0.01 to 0.1, preferably approximately 0.025.

41. Illumination system according to at least one of claims 1 to 40, further characterized in that

an accessible diaphragm plane is present.

42. Illumination system according to claim 41, further characterized in that a masking device is provided at the diaphragm plane, with which the type of illumination, particularly the coherency factor, annular or quadrupole illumination can be adjusted.

43. Illumination system according to one of claims 1-42, further characterized in that the light source is a synchrotron radiation source.

44. Illumination system according to claim 43, further characterized in that the light source is an undulator source or a wiggler source.

45. EUV projection exposure unit for microlithography



- with an illumination system according to at least one of claims 1 to 42
- a mask on a carrier system
- a projection objective
- a light-sensitive object on a carrier system.

46. EUV projection exposure unit according to claim 45, designed as a scanning system.

47. EUV projection exposure unit according to at least one of claims 43 to 46, further characterized in that the illumination intensity at the light-sensitive object—with an unstructured mask—has position-dependent differences that are less than  $\pm 5\%$ , preferably less than  $\pm 2\%$ .

48. EUV projection exposure unit according to one of claims 43 to 47, further characterized in that

the scan energy at the light sensitive object—with an unstructured mask—has position-dependent differences of less than  $\pm 5\%$ , preferably less than  $\pm 2\%$ .

49. EUV projection exposure unit according to at least one of claims 43 to 48, further characterized in that

a vacuum window transparent to EUV is arranged in the beam path.

50. EUV projection exposure unit according to claim 49, further characterized in that

a vacuum window is arranged at a constriction of the light bundle in the illumination system.

51. Process for the design of an illumination system for wavelengths  $\leq$  193 nm, particularly for EUV lithography, whereby the illumination system has:

- a light source with an illumination A in a predetermined surface,
- a mirror or lens device comprising at least two mirrors or lenses, which are comprising raster elements,
- optical elements, which are arranged between mirror or lens device and reticle plane,

comprising the following steps:

- 51.1 The raster elements of the first mirror or of the first lens are arranged in such a way that they cover the surface without overlapping;
- 51.2 The raster elements of the first mirror are shaped in such a way that their form corresponds to the field to be illuminated, whereby a secondary light source is assigned to each raster element;
- 51.3 The raster elements of the second mirror or lens are arranged in such a way that they sit at the position of the secondary light source.
- 51.4 The raster elements of the second mirror are shaped in such a way that their shape corresponds to that of the secondary light sources;
- 51.5 By rotating or tilting the raster elements of the first and second mirrors or by orienting and selecting the angle of deflection of

- the prismatic component of the raster elements of the first or second lens, a light path is produced between these, whereby a predetermined assignment of the raster elements of the first mirror or lens to the second mirror or lens is maintained, so that
- 51.6 the raster elements of the first mirror are imaged in the reticle plane by the raster elements of the second mirror;
- 51.7 the images of the raster elements of the first mirror are partially superimposed in the reticle plane;
- 51.8 the secondary light sources are imaged in the exit pupil by the optical elements.

52. Process for the production of microelectronic components, particularly semiconductor chips with an EUV projection exposure unit according to one of claims 43 to 50.

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